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A PRELIMINARY ASSESSMENT OF WETLAND, RIPARIAN, GEOMORPHOLOGY, AND FLOODPLAIN CONDITIONS AT SAND CREEK MASSACRE NATIONAL HISTORIC SITE, COLORADO

By
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Alexa Roberts PhD

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A Preliminary Assessment of Wetland, Riparian, Geomorphology, and Floodplain Conditions at Sand Creek Massacre National Historic Site, Colorado

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INTRODUCTION

In 2004, the Sand Creek Massacre National Historic Site (SAND) staff requested assistance from the Water Resources Division (WRD) to perform an assessment of existing water resource conditions at the park. Specifically we were asked to: 1) Perform a preliminary floodplain assessment and collect channel and floodplain data for subsequent hydraulic analysis, 2) Conduct a geomorphic and hydrologic assessment of the Chivington/Brandon Canal and identify opportunities to restore pre-disturbance floodplain hydrology, and 3) Identify wetland and soil baseline conditions and make recommendations that will be useful and necessary for park staff in their effort to create a master plan for SAND.

An interdisciplinary team consisting of hydrologists and wetland scientists from WRD visited the park in October, 2004 to perform these assessments. The team traversed the park property and evaluated the soils, and wetland and riparian habitat conditions, and then shot an elevation transect from the existing farm house across the floodplain and Big Sandy Creek.

Sand Creek Massacre National Historic Site is located in the east-central part of Colorado, near the town of Eads. Please see Figure 1 showing the current park boundary and the park boundary authorized by Congress for possible acquisition in the future.

CONDITIONS AND DISCUSSION

Soils

Most of the soils in the park are either sandy loams or loamy sands and are extremely dry and fragile most of the year. The soils on the south side of the creek are loamy sands and there are extensive areas of loamy sand on the north side of the creek. These have a brown loamy sand surface layer about 5 inches thick. The underlying material to about 60 inches is sand. Permeability is extremely rapid. These soils are highly susceptible to wind erosion. Blowouts, which are exposed sand dunes, occur frequently. Blowouts occur when the soils are overgrazed, plowed, or trampled by human traffic.

The soils on the slopes along the south side of the creek area are primarily Valent series. According to the NRCS, the Valent series scores the highest for wind erodibility out of all the 41 soil types in the county.

The effects of light foot traffic and wind erosion are obvious on the Valent soils around the Monument. Any extended foot traffic (from visitors or grazing animals) on these soils will quickly destroy the delicate cover of native grasses and expose the sand subgrade to wind erosion. The effort that went into the successful restoration of the farm road located just west of the Monument, done on slopes and soils very similar to those around the monument, is a good example of the tremendous effort needed to repair these damaged systems. Fran Pannebaker and Karl Zimmermann, Natural Resource Specialists at Bent's Old Fort National Historic Site and responsible for the restoration, have intimate knowledge of the species composition and vigor of the native and non-native prairie grasses, and will be able to make significant contributions to the design of the park master plan.

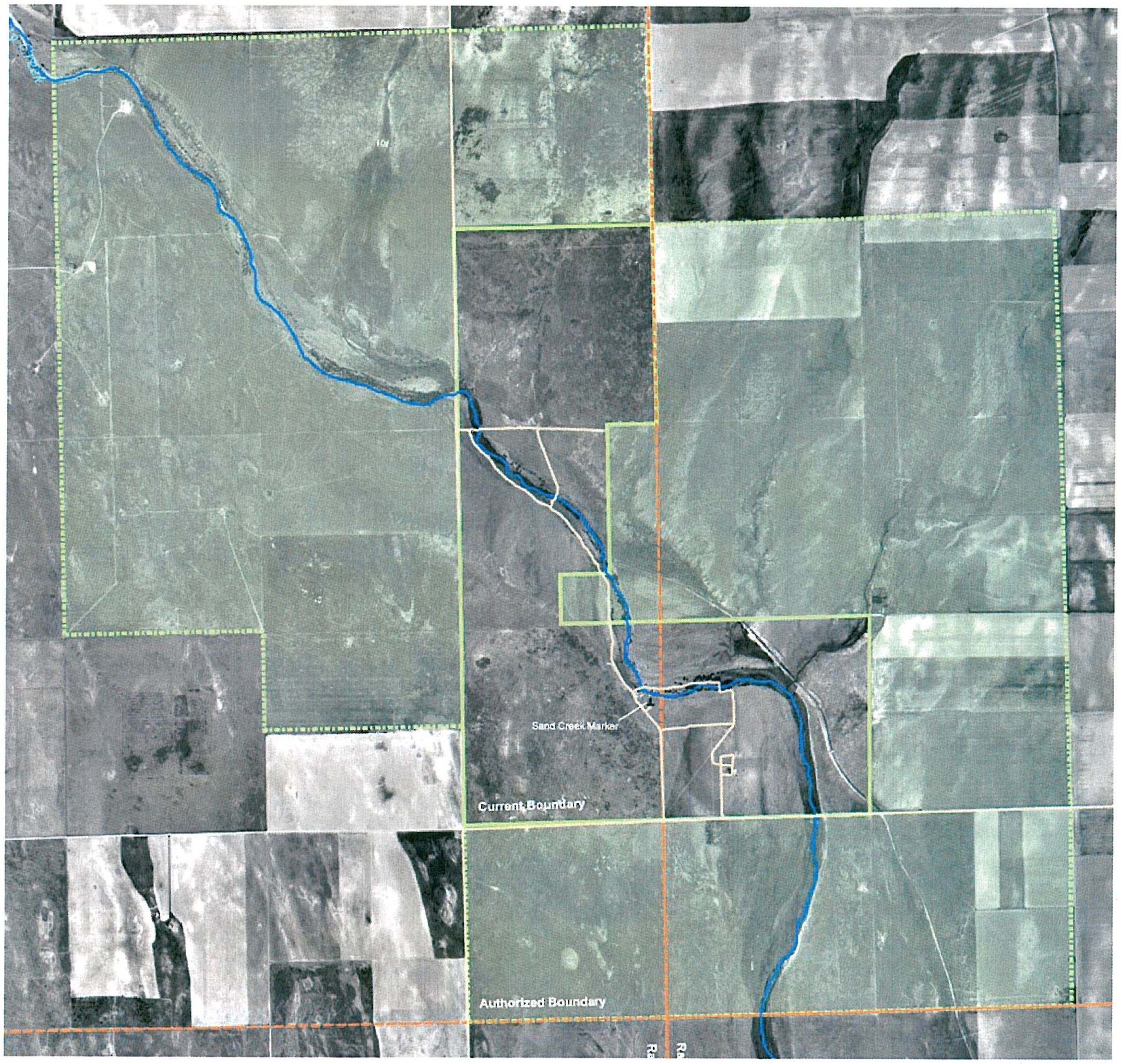

Figure 1: Sand Creek Massacre National Historic Site Current and Authorized Boundaries

Because of the sensitive soils, vegetation communities destabilize quicker than plant communities in other regions under minimal foot traffic. We recommend minimizing impact from visitor intrusion into the floodplain areas and north-side prairie terraces by limiting foot traffic and by controlling vehicle access.

Most of the access roads to and into SAND are unpaved compacted native soils. These soils are sandy and prone to wind and water erosion. The intersection of the primary access road W and the Big Sandy Creek, where the creek exits the south east edge of the current park boundary, is a significant erosion and maintenance problem. There are a few small culverts in place that allow only the minimum flow of the creek to pass. According to park staff, during frequent storm events the Creek overtops the road, erodes most of the road surface away, and the surface must be repaired.

Since the road systems will likely need upgrading to accommodate visitor use, the upgrading process will be an excellent opportunity to eliminate this problem. At the Big Sandy Creek and County Road W crossing, we recommend that a bridge or culverts be installed that are large enough to pass peak flows without eroding stream banks, damaging the road, or creating backwater flooding. We also recommend that the surface of the main entry roads bordering the site, and any roads into the park, be paved.

Salinity

Salinity levels were measured in two available surface water areas, one near the intake of the old canal (within the National Historic Site) and along county road W where Big Sandy Creek crosses the road. The salinity was 1.5 ppt in the upper pool and 3.6 ppt in the pool adjacent to county road W, both well above potability standards. These relatively high salinity levels are typical for this region due to the presence of gypsum ($CaSO_4$) in the bedrock. One management implication is that local groundwater may be more concentrated than allowable for public water supply. We recommend review of available information and possible analysis of existing wells prior to development of this resource.

Hydrology

Big Sandy Creek is an ephemeral stream flowing predominantly east and south, originating on the High Plains about 35 miles west of Limon, Colorado and forming a confluence with the Arkansas River just downstream of Lamar, Colorado. The watercourse has an overall length of about 100 miles and drains a large watershed in excess of 3,000 square miles. Despite the relatively large size of the drainage it is unlikely that this watershed produces extreme flood conditions due to the permeable soils and the gentle slope of the drainage.

The channel in the area of the National Historic Site generally displays poor development of the bed and banks suggesting that channel forming flows are rare. The channel that does exist occupies a broad, gently sloping floodplain that is bounded in some reaches by five to ten foot fluvial terraces. This greater morphology was likely formed under wetter conditions associated with previous glacial cycles and is not indicative of the current hydrologic regime.

The sandy porous soils reduce the amount of precipitation and overland flow reaching the stream course. A previous study conducted by the Army Corps of Engineers (COE 1974) concluded that north-side tributaries to the Arkansas River, including Big Sandy Creek, have large valley flood storage capacities and high infiltration rates in the adjoining soils. This combination of watershed conditions limits the magnitude of floods that may be produced by even extreme rain events. Nevertheless, historic flow data indicate that fairly substantial floods have occurred on occasion.

Two USGS operated gages (#07134000 and #07134100) exist on Big Sandy Creek; both are located about 25 miles downstream of the National Historic Site. The primary gage, Big Sandy Creek near Lamar CO (#07134100) drains a watershed of 3,248 square miles, 2,663 of which contribute flow to the watershed. Of the 23-year continuous record that began in 1968, almost 70 percent of the recorded peak flows are less than 500 cubic feet per second (cfs) and only two exceed 1000 cfs. The highest flow was recorded in May 1999 and reached a peak discharge of 2,850 cfs. The second highest flow occurred in September of 1976 and reached a peak of 2,520 cfs. For comparison, regional flood frequency equations developed for Eastern Colorado suggest that an "average" watershed of this size should have an annual flood in the range of about 1700 cfs (Ries and Crouse 2002). As stated, the annual peak flow on Big Sandy Creek is usually less than 500 cfs.

While severe floods do not appear to be a regular occurrence on Big Sandy Creek, drainages in this region of the State historically have experienced nuisance flooding resulting from highly localized summer thunderstorms (CWCB 1998). Flood elevations during these moderate events are exacerbated by undersized culverts and bridge crossings resulting in a backwater effect. Consequently, most flood damage associated with these local floods is to county roads and bridges with little inundation of populated areas.

Regulatory Floodplains and Directors Order 77-2

Regardless of the fact that Big Sandy Creek does not appear to be extremely flood prone, a flood regime does exist, and consequently, the NPS is obligated to manage the existing floodplains accordingly. Executive Order 11988 on Floodplain Management was issued in 1977 (and subsequently, the NPS adopted Directors Order 77-2 and the companion Procedural Manual, PM 77-2 to implement the Executive Order with respect to NPS lands). The Directors Order applies to all NPS actions, including the direct and indirect support of floodplain development that could adversely affect the natural resources and functions of floodplains or increase flood risks. The Directors Order also applies to roads and to actions that are functionally dependent upon water such as water intake facilities, sewage outfalls, and bridges.

The Directors Order states that, when managing floodplains, the NPS will specifically: protect, preserve and restore the natural resources and functions of floodplains; avoid the long- and short- term effects associated with the occupancy and modification of floodplains; avoid direct and indirect support of floodplain development and actions that could adversely affect the natural resources and functions of floodplains or increase the flood risk; and restore when practicable, natural floodplain values previously affected by land use activities within floodplains. When it is not practical to locate or relocate development to a site outside of the floodplain the NPS will: prepare and approve a Statement of Findings in accordance to procedures described in PM 77-2, take all responsible actions to minimize the impact to the natural resources of floodplains, use non-structural measures as much as practicable to reduce hazards to life and property, and ensure that structures and facilities are designed to be consistent with criteria of the National Flood Insurance Program.

To implement the NPS floodplain policy, a proposed action will be classified as fitting into one of three classes: Class I or the Base Floodplain, Class II or the Critical Action Floodplain, and Class III or the High Hazard Area. Class I Actions include location or construction of administrative, residential, warehouse and maintenance buildings; non-excepted parking lots; or other man-made features which by their nature entice or require individuals to occupy the site, are prone to flood damage, or result in impacts to natural floodplain values. Class I actions are subject to floodplain policies if they lie within the 100-year floodplain.

Class II Actions include any activity for which even a slight chance of flooding is too great. Examples of Class II Actions are the location or construction of: Schools; hospitals; fuel storage facilities; sewage treatment plants in excess of 40,000 gallons per day; storage of toxic, hazardous, or water-reactive materials; irreplaceable records; museums; and storage of archeological artifacts. Class II Actions are subject to the floodplain policies if they lie within the 500-year floodplain. Class III Actions include Class I or Class II Actions in high hazard areas such as areas subject to flash flooding. Class III Actions are subject to floodplain policies if the lie within the Extreme Floodplain. Due to the nature of the Big Sandy Creek watershed, Class III actions do not apply at SAND.

Specific to SAND, most future actions will be in the Base Floodplain and fall into Class I, therefore, actions may be subject to 100-year floodplain compliance. Possible exceptions could be fuel or irreplaceable artifact storage which is subject to 500-year floodplain compliance. The first step in determining the location of the 100-year floodplain (or any other regulatory floodplain) is estimating the magnitude of such a flood in this drainage. Once a magnitude is determined the discharge must be translated into a stage or depth at the site(s) of interest through hydraulic modeling.

The Colorado Water Conservation Board conducted a Log-Pearson III statistical analysis of the existing peak flow record at the primary USGS gage to estimate flood recurrence intervals and associated magnitudes. The relatively short record of 23 years produced an estimate for the 100-year flood of 2,577 cfs (CWCB 1998). Other methods exist for estimating design flood discharges, however, even with the short record of 23 years, using drainage specific data is more appropriate than indirect methods. Consequently, we will adopt 2,577 cfs as the 100-year discharge for this drainage. Since SAND is actually located about 25 miles upstream from the gage, this estimate of the 100-year flood magnitude is somewhat high and therefore will provide a conservative estimate of the floodplain boundaries.

Site Specific Flood Hazard Assessment

Presently the park has no on-site infrastructure and no specific locations for proposed facilities. Consequently, the flood hazard assessment must be general in nature and serve as a guideline for future development. To develop this general guideline, we selected (with the advice of park staff) a likely location for the placement of a visitor center, surveyed a detailed channel and floodplain cross section and performed a preliminary hydraulic analysis to estimate the extent of the 100-year floodplain.

The site chosen for the preliminary analysis was the river reach adjacent to the Dawson Ranch Headquarters. The former ranch house is situated on a right-bank terrace about four to six feet above the elevation of the greater floodplain. This greater floodplain is over 2000 feet wide and is bounded by terraces on each side. We surveyed one channel and floodplain cross section from terrace to terrace to estimate flood elevations using the Manning equation. Surface roughness values were estimated based on past experience and stream slope values were obtained from USGS topographic maps. In all facets of this analysis, we erred on the side of conservancy to determine potential development areas well outside of the 100-year floodplain. Even with this attempt, it is important to realize that the Manning equation does not account for any backwater effect and therefore actual flood elevations could be higher than reported. Consequently, any development that may approach a floodplain boundary will require a more rigorous analysis.

The estimated 100-year flood discharge of 2577 cfs will easily fill the poorly defined channel and spill on to the greater floodplain. However, given the floodplain width of over 2000 feet in this reach, the 100-year flood will achieve a depth of less than two feet in the floodplain and on overall flood width of about 1000-1500 feet, indicating that any location on the terrace level is well outside of the regulatory floodplain (Please see the Figure 2). Additionally, much of the area of the greater floodplain is also likely outside of the regulatory flood and therefore may be developed without a Floodplain Statement of Findings. Nevertheless, any site on the greater floodplain selected for possible development will warrant a more specific analysis.

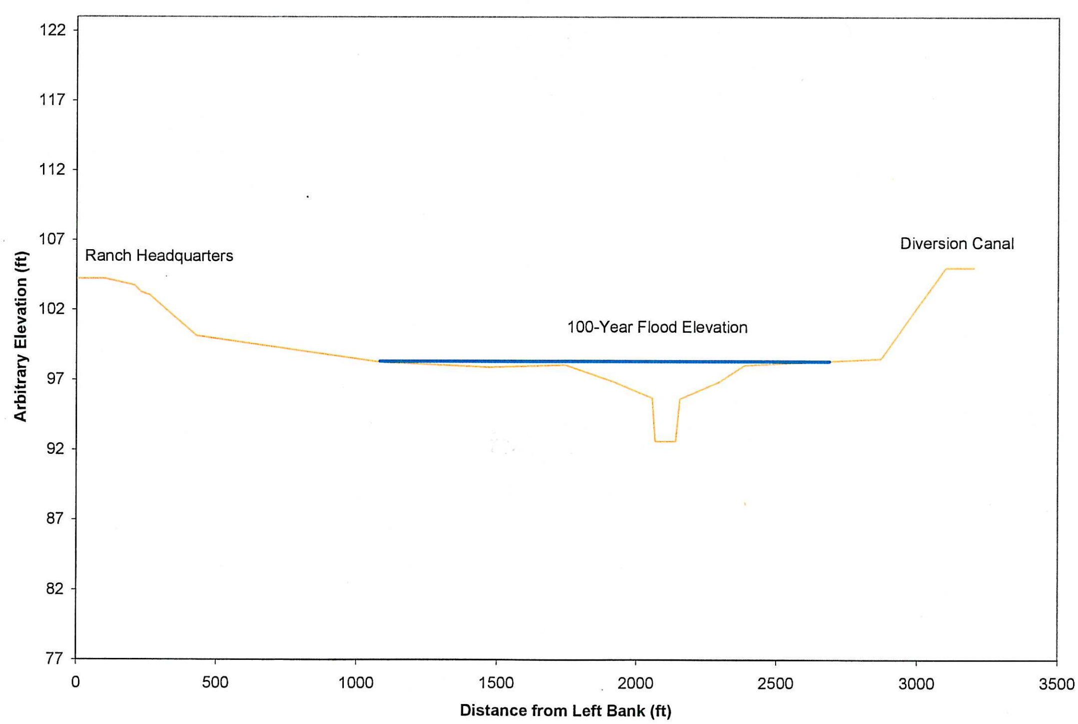

Figure 2: 100-Year Floodplain

One particularly sensitive site-specific concern is the future placement of a cemetery area, as specified in the park's authorizing legislation. The legislation permits the establishment of a cemetery area for the interment of human remains and associated items that might be discovered on the massacre site or that Cheyenne and Arapaho descendents may repatriate from museums in the future. WRD staff recommended that subsurface hydrologic conditions be carefully defined in order to locate an appropriate cemetery site. The ground water elevations vary throughout the various floodplain terraces. Therefore, if water inundation of the remains would cause problems, park staff would have to install shallow ground water monitoring wells at potential burial locations. Monitoring data from the wells would show seasonal fluctuations of the subsurface groundwater levels. This would give the park staff and tribal representatives enough information to decide on where the site should be. If water inundation is not a problem, then any burial site, located outside the floodway would be appropriate. Regardless of where it is located, the burial site would not interfere with floodplain processes and therefore would not require any compliance with Directors Order 77-2.

Hydraulic Problems with the County Road W Crossing

Backwater may play a role in determining flood elevations especially in reaches just upstream from road crossings. Road crossings over broad floodplains usually represent an extreme reduction in flow width that greatly reduces flood conveyance. Just downstream of the Dawson Ranch Headquarters is a prime example - the county road W crossing (Figure 3).

Figure 3: Big Sandy Creek at County Road W

We inspected this site (located on the boundary between Section 30 and 31, Township 17S, Range 45W) and estimated the unobstructed flow width of Big Sandy Creek to be about 90 feet wide. In contrast, the single culvert that allows water to pass under the road appeared to have a three-foot diameter. This represents a constriction ratio of about 30: 1. Not surprising, overtopping of the road and associated erosion is very common during flow events. Besides being a maintenance liability, road material is washed downstream into the riparian wetland system. We recommend improving flows under the road with a bridge, new box culverts, or numerous large culverts.

Erosion and Surface Runoff Problems in the Irrigation Canal

The Chivington/Brandon Irrigation Canal is a ditch and levee structure that begins in about the center of the current park land holdings and extends more than a mile to the south east corner. Remnants of the canal extend for another 20 miles. The ditch measures approximately 40 feet wide, and the base of the levee is approximately 40 feet wide.

Earth was excavated to create the canal channel and side cast towards the creek floodplain, forming a levee along the east edge of the floodplain. The levee effectively collects surface flow from numerous small tributaries and diverts them along the inside of the levee to one point approximately 5,000 feet above county road W, where the water flows into the Kern spring tributary and out into the floodplain.

After almost 100 years of neglect, the bottom of the canal has eroded down below its original design grade. As a result, there are numerous "head cuts" which are areas in the channel bottom that are eroding at significantly higher rates than what would erode from within a stable stream channel. Most of the head cuts north of the Kern spring stream crossing appear to be slowing down. There is, however, one head cut that should be stabilized to stop the erosion migration and to reduce sediment loading downstream. It is located just south of where the Kern spring stream crosses the levee. Please see Figure 4.

Figure 4: Head Cut Erosion within Canal Channel

The entire levee commands a great view of the floodplain and the National Historic site. Park staff suggested that the levee could be used as a trail since the soils are disturbed (side-cast from the ditch) and the steep side slopes of the levee would tend to discourage people from wandering off the trail. Access would have to be carefully planned, with access from parking on the north side.

The canal levee diverts the natural surface drainage from the adjacent hills into a concentrated outflow within the canal channel. Old stream channels that existed in the floodplain below the canal levee are still visible. We would prefer that the natural surface flows be restored through these channels. However, this would require breaching the levee at certain intervals which could be cost prohibitive and may visually impact the historic feature. We recommend that this be a long-term option, but with low priority.

Impact to Wetlands from Groundwater Development

Park staff expressed concerns over the possible impact to wetland and riparian systems resulting from pumping groundwater from the alluvial aquifer for the park's domestic water supply.

Jenkins (1970) described a method for computing streamflow depletion from pumping of nearby wells. Pumping groundwater from alluvial aquifers that are hydrologically interconnected with surface flow in streams can result in reducing the amount of streamflow (streamflow depletion). In the most extreme cases, where large-volume wells are located close to a stream, pumping can induce infiltration of surface water into the alluvial aquifer creating a very obvious reduction in streamflow (particularly for small streams).

A more subtle form of streamflow depletion occurs with smaller-volume wells and wells that are located further from a stream. In this case streamflow depletion occurs as a reduction of the amount of groundwater flowing toward and discharging to the stream. Water is not withdrawn from the stream, but streamflow does not increase as much as it would have if all of the groundwater had been allowed to flow toward, and discharge into the stream.

Streamflow depletion (q) is generally computed as a ratio of the depletion to the pumping rate of the well (Q). For example a ratio of q/Q of 0.01 indicates that the streamflow is depleted by an amount equal to 1 % of the pumping rate of the well. The ratio is not affected by the pumping rate of the well. It is controlled by the distance from the stream to the well and the hydraulic characteristics of the alluvial sediments. As would be expected, streamflow depletion is greater for wells that are closer to a stream and environments where the alluvial sediments have a higher permeability.

As an example of the potential for streamflow depletion at Sand Creek, assume:

a = 2000 feet, distance to stream
S = 0.15, specific yield of the aquifer
T = 500^2 ft /day, transmissivity of the aquifer where,
T = Kb, hydraulic conductivity times thickness of the aquifer
K = 10 feet/day, hydraulic conductivity of the aquifer
b = 50 feet, thickness of the aquifer

Then the stream depletion factor (sdf) is computed as:

$$sdf = \frac{a^2 S}{T} = \frac{(2000\,feet)^2 (0.15)}{500\,feet^2 / day} = 1200 days$$

Then if we assume that the well is pumped continuously for 100 days (t = 100 days):

$$\frac{t}{sdf} = \frac{100 days}{1200 days} = 0.0833$$

From the tables and type curves presented by Jenkins (1970), we see that for:

$$\frac{t}{sdf} = 0.0833 \ldots \frac{q}{Q} \approx 0.01$$

These computations would lead us to believe that after 100 days of pumping, streamflow depletion would be approximately 1% of the pumping rate. As the amount of time that the well is pumped increases, the stream depletion factor also increases until, theoretically, it approaches 100% o f the pumping rate. However, several factors will reduce the true impact of groundwater pumping on streamflow at Sand Creek.

The long-term average pumping rate for a water supply well at Sand Creek will be in the range of 1-2 gallons per minute (5 gpm is 7200 gallons per day), so even 100% depletion is a very small amount.

The mathematical solution for this method of assessing potential streamflow depletion assumes that the stream channel fully penetrates the aquifer. At Sand Creek, the stream channel only penetrates the top few feet of the aquifer, probably no more than 10% penetration. Thus, there is much less hydrologic interaction between streamflow and groundwater.

Although it is possible to calculate an amount of streamflow depletion from pumping a water supply well at Sand Creek, the net effect is infinitesimally small. About 90% of the groundwater that is pumped from the well will be recharged into the alluvial aquifer by infiltration from the septic leachfield. The net hydrologic effect will be the same as if the pumping rate was reduced by 90%.

The net effect of groundwater pumping will be negligible because: 1) the well will not be located very close to the creek, 2) a fairly small amount of water will be pumped, and 3) most of the water that is pumped will be returned to the local aquifer as infiltration from the septic leachfield.

Wetland and Riparian Areas

Fluvaquents are the soils that comprise the immediate floodplain areas on either side of the creek channel. These soils are not suited for much of anything but wildlife habitat. These areas have a high water table that ranges in depth from 1 to 3 feet during an average spring season. The high water table supports the growth of willows and cottonwoods and a variety of other riparian and wetland plant species and habitats. Most of the stream channel and the ponded surface waters are wetlands.

The riverine and palustrine wetland areas increase in area along the Big Sandy Creek channel floodway for a distance of approximately 4,000 feet north from the county road W crossing, to where the Kern spring channel intersects with the Big Sandy Creek channel (please see Figures 5 and 6). The Kern spring is a perennial flow that supplies surface water to the creek floodplain. As a result, the wetlands are larger and more frequent along the 4,000-foot strip than in the channel floodway above the confluence.

Figure 5: Confluence of Big Sandy Creek and Kern Spring Channels

The cottonwood groves, stream morphology, and wetland areas in the immediate floodplain and channel seem to be stable and properly functioning.

We observed some individual, heavily browsed, willow saplings within the fluvaquent soils. Knowing that herbivores prefer willow as forage, we believe that stands of willow (and cottonwood) were typical in the historic scene at the time of the massacre and that livestock grazing has reduced the plant density and vigor significantly. We also feel that willow communities are an important component of the wildlife habitat along these riparian areas. Therefore, we recommend a willow establishment program be initiated.

Specifically, willow cuttings should be taken from appropriate donor sites in the watershed in early spring (prior to leaf out) and planted at suitable locations (with appropriate hydrologic conditions) along the Sandy Creek and Kern spring channels. These plantings would need to be protected from livestock grazing so that they can develop into mature thickets consistent with the historic landscape.

Figure 6: Southern Portion of the Current Park Area

Any proposed alterations such as trails, boardwalks, roads, or structures to the wetlands (including the stream channel of the Kern spring flow) in the fluvaquent soils will require a wetland delineation, analysis of impacts to wetland functions, and may require a Wetland Statement of Findings prepared according to NPS Procedural Manual 77-1: Wetland Protection.

CONSIDERATIONS AND RECOMMENDATIONS FOR FUTURE ACTIONS

The soils, hydrology, and wildlife habitat on the SAND site are extremely sensitive to human traffic and other alterations. The contractor or whoever develops the site plan schematic design, conceptual design, final design, and construction drawings for the park visitor circulation, infrastructure, and buildings must complete a thorough assessment and understanding of baseline conditions. We recommend that the authors and others within the Water Resources Division, NPS, be part of a team that is advisory to the planning and design team.

All soils in the park are extremely sensitive to foot traffic and wind erosion. Since most of the visitor activity and infrastructure is likely to occur on the south side of the park, where the sandy loams are located, care should be taken to control circulation through the park and control access by visitors and grazing animals into any areas in the park. The NRCS recommends that on these soils foot traffic and grazing should be managed to protect the grasses and organic layer by leaving a good height of grasses standing to protect the soil from blowing and to catch and hold snow.

For floodplain compliance specific to SAND, most future actions will fall into Class I and, therefore, be subject to 100-year floodplain compliance. Possible exceptions could be fuel or irreplaceable artifact storage which is subject to 500-year floodplain compliance. Given that broad geomorphic floodplain (roughly 2000 feet in some areas) and the limiting hydrologic factors of the watershed, the 100-year flood will only achieve minimal depths and overall flood widths. Consequently, much of the area on the fringes of the greater floodplain and all locations on the higher terrace are likely outside of the regulatory floodplain. Final site locations may warrant more specific floodplain analysis.

To alleviate or at least reduce the detrimental effects of the undersized passage of Big Sandy Creek under County Road W, we suggest replacing the steel culvert with a properly sized box culvert. If that approach is cost prohibitive, then at least several culverts could be installed to reduce the degree of constriction. Hydraulically, the most favorable crossing would be a bridge spanning a large portion of the floodplain, however, this option is likely cost restrictive.

Stabilize the eroding head cut within the canal channel located just south of the spring stream crossing. This might be accomplished by excavating the wall of the head cut back and up the stream channel, creating a 3:1 or 4:1 slope along the centerline of the channel. The finished grade would have to be planted with appropriate grasses and temporarily protected with a stabilizing fabric.

The net effect of groundwater pumping will be negligible because; 1) the well will not be located very close to the creek, 2) a fairly small amount of water will be pumped, and 3) most of the water that is pumped will be returned to the local aquifer as infiltration from the septic leachfield.

Salinity levels in the local groundwater may be more concentrated than allowable for public water supply. We recommend review of available information and possible analysis of existing well waters prior to development of this resource.

The limits of the fluvaquent soils in the floodplain of Big Sandy Creek, as defined in the Kiowa County Soil Survey, should be used to define the limits of the riparian and wetland systems for planning purposes. Any proposed modifications in the fluvaquent soils will require a wetland delineation and possibly a Wetland Statement of Findings.

We recommend a willow planting program be initiated to reestablish willow communities. These areas would have to be protected from intense cattle grazing.

If cattle are used to manage the grasslands or for fire fuel suppression, we recommend that they be excluded from the sensitive soil and wildlife habitat along steep slopes, and in wetlands and riparian areas. If possible, maintain the appropriate animal units on the property that mimics the effects of what would have been buffalo, deer, and elk grazing in the historic scene. If necessary, develop a fencing exclusion plan to protect the sensitive areas. Fran Pannebaker and Karl Zimmermann, Natural Resource Specialists at BEOL, have intimate knowledge of the species composition and vigor of the native and non-native prairie grasses, and will be able to make significant contributions to the design of the park master plan.

Before the park opens to the public, we recommend that park staff establish and maintain a network of photograph station points. A thorough photographic record of the wetland, riparian, and range conditions at the park will be useful in the future for evaluating change in habitat conditions. The station points should be marked in the field with one-inch diameter rebar or metal fence post that rises at least two feet above ground. The station locations should also be numbered and located on a digital aerial photograph.

Figure 7: View from the Monument Looking Northwest

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As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

SAND D6.   June 2005